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(54) Title of the Invention: Bank Note Discriminating Device

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Specification

1. Title of the Invention

Bank Note Discriminating Device

2. Claims

(1) A bank note discriminating device, wherein the bank note discriminating device is equipped with a detecting means for detecting the physical quantity of a bank note, a zone setting means for setting a plurality of detection signal zones for the extracted series of signals obtained by the detecting means, and a determining means for determining the denomination of the bank notes based on the detection signals in the zones set by the zone setting means.

(2) The bank note discriminating device in Claim 1, wherein the discriminating means comprises a calculating portion for performing calculations on the detection signals in each zone set by the zone setting means, and a discriminating portion for discriminating the denomination of the bank notes based on the results of the calculating portion.

(3) The bank note discriminating device in Claim 2, wherein the calculating portion is a differentiating means for differentiating between detection signals.

(4) The bank note discriminating device in Claim 1, wherein the physical quantity refers to the amount of reflected light.

(5) The bank note discriminating device in Claim 1, wherein the physical quantity refers to the amount of light passing through the bank note.

(6) The bank note discriminating device in Claim 1, wherein the physical quantity refers to the amount of magnetism in the bank note.

(7) The bank note discriminating device in Claim 2, wherein the calculating means is a comparison means that compares the detection signals in the different zones set by the zone setting means to the preset reference signals for the different zones and counts the results of the comparison.

3. Detailed Description of the Invention

(Industrial Field of Application)

The present invention relates to a bank note discriminating device for a device that handles bank notes such as a money-changing machine or an automatic teller machine.

(Prior Art)

Money-changing machines and automatic tellers machines in banks and other financial institutions have a built-in bank note discriminating device for determining the denomination of bank notes inserted into the machines by customers. In order to be more convenient, customers are allowed to insert large numbers (up to 100) of bank notes in three denominations (10000-yen, 500-yen and 1000 yen) into these machines at a high speed and in any direction. The bank note discrimination device detects the amount of light reflected from a bank note, the amount of light passing through a bank note or the magnetic pattern on a bank note to determine its denomination and to determine that it is real (or counterfeit). However, there are too many detection patterns if the bank notes are inserted any which way even for bank notes of the same denomination. As a result, the detection pattern has to be selected based on the manner in which the bank note was inserted into the machine in order to compare the bank note to the proper detection pattern. Therefore, the denominational orientation of the bank note has to be determined before determining if the bank note is real. For example, the three denominations (10000-yen, 500-yen and 1000 yen) of bank notes can be inserted with four different orientations (front, back, left, right) for a total of 12 different denominational orientations. This is very important because bank notes subsequently and mistakenly deemed to be counterfeit will be rejected.

Bank note discriminating devices of the prior art detect the physical quantity of a bank note and then determine the denomination and orientation of the bank note. In other words, the outside dimensions of a bank note, the amount of light reflected from the bank note, the amount of light passing through the bank note or the magnetic pattern on the bank note is detected, the detected pattern is compared to preset reference

patterns in all denominational orientations, and the reference pattern most closely matching the detected pattern is used to determine the actual denominational orientation of the bank note. Similarly, the detected pattern is divided into a number of zones of equal size, the zones are compared to reference values, and the results of the comparison are used to determine the denominational orientation of the bank note. A calculation performed on several partitioned blocks can also be used to determine the denominational orientation of a bank note.

(Problem Solved by the Invention)

The following is a description of the problem with the prior art technology.

In the method using the outside dimensions to determine the denomination of a bank note, malfunctions often occur because the bank note is partially shrunk, folded or torn. Because the dimensional detection has to be extremely precise, expensive high-performance sensors also have to be used. Any dimensional discrepancy in a given bank note will also cause a malfunction.

In the method comparing the detected pattern to a reference pattern, a single bank note has to be compared to all of the reference patterns. This amounts to 12 reference patterns when three denominations (10000-yen, 500-yen and 1000 yen) of bank notes are inserted with four different orientations (front, back, left, right). This process takes a long time and cannot be used in high speed processing. High performance hardware that reduces the amount of processing time is expensive.

In the method that divides the detection pattern into zones of the same size to determine the denominational orientation, bank notes with similar designs confound the logic operation. Many of the zones are very similar in design and any stains or wrinkles on the bank notes are likely to cause a malfunction.

In order to solve these problems, the purpose of the present invention is to provide a bank note discriminating device that is able to determine the denominational orientation of a bank note quickly and inexpensively even when the bank note is stained, wrinkled, folded or partially torn.

(Means of Solving the Problem)

The present invention is a bank note discriminating device, wherein the bank note discriminating device is equipped with a detecting means for detecting the physical quantity of a bank note, a zone setting means for setting a plurality of detection signal zones for the extracted series of signals obtained by the detecting means, and a determining means for determining the denomination of the bank notes based on the detection signals in the zones set by the zone setting means.

(Operation)

In the present invention, the detecting means detects a physical quantity such as the amount of light reflected off a bank note, the amount of light passing through a bank note or the magnetic pattern on a bank note. The zone setting means sets the detection signal zones from the series of detection signals obtained from the detecting

means so as to be able to accurately detect the special characteristics of various denominational orientations. Because the discriminating means determines the denominational orientation of the bank notes based on the detection signals in each zone, the denominational orientation of a bank note can be determined in a short period of time and is not adversely affected by stains, wrinkles, folds and tears.

(Working Examples)

The following is an explanation of a working example of the present invention with reference to the drawings.

FIG 1 is a block diagram of the bank note discriminating device in a working example of the present invention. FIG 2 is a drawing of the sensor array in the bank note discriminating device.

The following is a description of the sensor array with reference to FIG 2. Here, a bank note indicator 23 for indicating the arrival of a bank note 22 via the conveyor means (not shown) and a detector 24 for detecting the amount of light reflected off the bank note 22 are arranged above the conveyor route 21. The bank note indicator 23 arranged above the conveyor route 21 consists of a light source 25 for providing light (such as a light-emitting diode or LED) and a light-receiving sensor 26 for detecting the light from the light source 25 via conveyor route 21 (such as a photodiode). The detector 24 consists of a light source 27 for providing light (such as an LED) and a light-receiving sensor 28 (such as a photodiode) arranged at a set interval from the light source 27. A light source 27 and a light-receiving sensor 28 are arranged at four points

in a direction perpendicular to the direction in which the bank notes 22 are being conveyed.

The following is a description of the device in a working example of the present invention with reference to FIG 1. In FIG 1, the components identical to those in FIG 2 are denoted by the same numbers. The output terminal on the detector 24 is connected to the input terminal on the amplifying circuit 1, and the detector 24 outputs the brightness of the reflected light from a bank note 22 and the result is used to output the corresponding electric signal. The output terminal on the amplifying circuit 1 is connected to the input terminal on the multiplexer 2, and the amplifying circuit 1 amplifies the output signal from the detector 24 and outputs it.

The output terminal on the bank note indicator 23 is connected to the input terminal on the timing signal generating circuit 10, and a bank note indicating signal t1 is outputted. The multiplexer control signal (t2) output terminal on the timing signal generating circuit 10 is connected to the control signal input terminal on the multiplexer 2, and the sampling clock signal (t3) output terminal is connected to the sampling clock input terminal on the analog-to-digital conversion circuit 3 explained below. The write address signal (a1) output terminal and the memory storing control signal (t4) output terminal are connected to the write address signal input terminal and the memory storing control signal on the memory circuit 4 described below. The bank note throughput signal (t5) output terminal is connected to the bank note throughput signal input terminal on the discrimination control circuit 11 described below. The output terminal on the multiplexer 2 is connected to the analog signal input terminal on the analog-to-digital conversion circuit 3. The multiplexer control signal t2 selects one of

the input signals (S1, S2, S3, S4) from one of the four amplifying circuits 1 and outputs it. The data output terminal on the analog-to-digital conversion circuit 3 is connected to the data input terminal on the memory circuit 4. It is synchronized by the sampling clock signal t3 from the timing signal generating circuit 10, and the analog input signals are converted to digital signals are then outputted.

The read address signal (a2) output terminal and the read memory control signal (t6) output terminal on the discrimination control circuit 11 are connected to the read address signal input terminal and the read memory control signal output terminal on the memory circuit 4 described below. The integrating circuit control signal (t7) output terminal is connected to the control signal input terminal on the integrating circuit 5 described below, and the slice level memory circuit control signal (t8) output terminal is connected to the control signal input terminal on the slice level memory circuit 7 explained below, and the counting circuit control signal (t9) output terminal is connected to the control signal input terminal on the counting circuit 9 described below. The discriminating circuit control signal (t10) output terminal is connected to the control signal input terminal on the discriminating circuit 6 described below.

The data (S5) output terminal on the memory circuit 4 is connected to the data input terminal in the integrating circuit 5 described below and the data input terminal on the comparator 8 described below. Data (S5) to be stored in the circuits is outputted based on a read address signal (a2) and a right address signal (t6) from the discriminator control circuit 11. The output terminal on the integrating circuit 5 is connected to the integrating value input terminal on the discriminating circuit 6 described below. An integrated value I is outputted based on the control signal (t7).

The output terminal on the slice level memory circuit 7 is connected to the slice level input terminal on the comparator 8, and the slice level S6 is outputted based on a control signal t6. The output terminal on the comparator 8 is connected to the count input terminal on the counting circuit 9, and result S7 of a comparison of the data S5 and the slice level S6 is outputted. The output terminal on the counting circuit 9 is connected to the count value input terminal on the discriminating circuit 6 described below, and a count value S8 is outputted based on the control signal t9. The output terminal on the discriminating circuit 6 is connected to the discrimination result input terminal on another circuit (not shown), and the discrimination result is outputted based on the integrated value I, the count value S8 and the control signal t10.

The following is an explanation of the operation of the device in the working example of the present invention. In this working example, there are four orientations (front, back, left, right) of three denominations (10000, 5000, 1000) or 12 denominational orientations. The denominational orientations are determined using the degree of reflected light from the bank notes. When a bank note 22 is conveyed to the device by a bank note conveyor means (not shown), the bank note is detected by the bank note indicator 23, and the bank note indicator 23 outputs a bank note indicating signal t1. After the bank note is indicated by the bank note indicator 23, the detector 24 detects the amount of light reflected off the surface of the bank note 22. The four signals S1, S2, S3, S4 detected by the four detectors 24 are amplified and outputted from four amplifying circuits 1. The bank note 22 is scanned in the direction of conveyance.

FIG 3 (a) shows the series of detection signals S1 obtained from the bank note 22. The analog series of detection signals S1 are converted to digital signals by the analog-to-digital converter 3 based on the sampling clock signal t3 shown in FIG 3 (b). The series of converted sampling data S5 is shown in FIG 3 (c).

When a bank note indicating signal t1 is inputted, the timing generating circuit 10 outputs a bank note throughput signal t5, a multiplexer control signal t2 synchronized to the traveling speed of the bank note 22, a sampling clock signal t3, a write address signal a1, and a memory write signal t4. As shown in FIG 4, when the bank note indicating signal t1 changes from "0" to "1", the multiplexer 2 selects detection signal S1 based on multiplexer control signal t2, and the signal is outputted to the analog-to-digital conversion circuit 3. Detection signal S1 is converted to a digital signal by the analog-to-digital conversion circuit 3 based on sampling clock signal t3. The digitally converted data is then stored in address "0" in memory circuit 4 based on write address signal a1 and memory write signal t4. Detection signals S2, S3 and S4 undergo analog-to-digital conversion in the same manner and are stored in addresses "1", "2" and "3" of the memory circuit 4. When another bank note passes through and the bank note indicating signal t1 changes from "1" to "0", the sampling and storage process continues. After a single bank note has been sampled and stored, the contents of the memory circuit 4 appear as shown in FIG 5. The relationship between the content of the memory circuit 4 and the sampled position of the bank note 22 are shown in FIG 6.

When a bank note has passed through and been sampled and stored, a bank note throughput signal t5 is outputted as shown in FIG 4 and the discrimination control circuit 11 begins to operate. So the discrimination control circuit 11 is able to accurately

determine the denominational orientation of the bank note, the memory circuit 4 stores detection signals S1T2 ~ S1T5 in Zone B1, detection signals S1T6 ~ S1Tm1 in Zone B2, detection signals S2T4 ~ S2Tm2 in Zone B3, detection signals S2Tm3 ~ S2Tm in Zone B4, detection signals S3Tm4 ~ S3Tn-1 in Zone B5, and detection signals S4T3 ~ S4Tm5 in Zone B6 as shown in FIG 6. The position and length of the sensor scanning track are optional. An address is indicated in each zone of the memory circuit 4 based on the read address signal a2, and sampled stored data is outputted to the data output terminal of the memory circuit 4 based on the memory read signal t6.

The control signals t7 consist of clear signal 7-1 indicating the start of the addition process in a given zone and a sampling data validation signal 7-2 indicating the sampling data S5 in the zone read from the memory circuit 4 is valid. The clear signals 7-1 is used by the integrating circuit 5 to clear the integrated value I, and the sampling data validation signal 7-2 is used to add up the sampling data Sn in the zone read from the memory circuit 4 and create integrated value I. The slice level memory circuit 7 outputs the slice level S6 set for each zone to the output terminal so as to easily extract the special characteristics of each denomination based on the control signal tn. The comparator 8 compares the relative size of the sampling data S5 and the slice level S6 as shown in FIG 3 (c) and outputs the comparison result S7 to the counting circuit 9. The counting circuit 9 uses control signal t9 to clear the counting result S8, counts the comparison result S7 of the comparator 8, and outputs the comparison result S8 to the discriminating circuit 6. The discriminating circuit 6 uses control signal S10 to read the integrated value I and the counting result S8. The timing chart for these signals is shown in FIG 7.

The integrated value I and the counting result S8 are then compared to the preset reference values in each zone. As shown in FIG 8, the various denominations are identified using the reference values in each zone. For example, if the integrated value I in Zone B1 is smaller than the reference value, the bank note is 10,000A, 10,000B, 5000B or 5000C. The letter following the denomination refers to the four orientations (front, back, right, left). In this process, the integrated value I and counting result S8 for each zone (B1 through B6) are determined, the integrated value I and counting result S8 in each zone are compared to the proper reference values, and the denomination of the bank note is identified using the logic value of the result of the comparison.

In this working example, the six zones of one side of a bank note 22 are extracted from the signals detected by the four detectors 24, each zone is integrated and compared, and the results identify the denomination. A minimum of four zones is required to process the four orientations (front, back, left, right) of three denominations (10000, 5000, 1000) or 12 denominational orientations. However, more zones should be added in order to reduce the number of misidentifications of bank notes. In this working example, the bank notes were identified using reflected light. However, other physical quantities include the amount of light passed through a bank note and the magnetic ink pattern on a bank note. The working example had a simple hardware configuration consisting of an integrating circuit 5, a discriminating circuit 6, a comparator 8, a counting circuit 9 and a discrimination control circuit 11. These can, of course, be operated using a microcomputer program.

(Effect of the Invention)

As explained above, the present invention is a bank note discriminating device in which a plurality of detection signal zones are set for the extracted series of signals obtained by the detecting means from a physical quantity of the bank note. As a result, the denomination of the bank note can be determined in a short period of time and the process is less adversely affected by stains, wrinkling, partial folding and tears in the bank note. Because the data used to perform the discrimination process on the denominational orientation can be compiled with a high degree of latitude, new types of bank notes can be added to the device easily and without changing the detection method.

4. Brief Explanation of the Drawings

FIG 1 is a block diagram of the bank note discriminating device in a working example of the present invention. FIG 2 is a drawing of the sensor array in the device shown in FIG 1. FIG 3 shows an example of a detection signal S_1, a sampling clock signal t_3 and a sampling data signal S_5. FIG 4 is a timing chart of the output from the timing signal generating circuit. FIG 5 shows the content of the memory circuit. FIG 6 shows the relationship between the sampling position of a bank note and the content of the memory circuit. FIG 7 is a timing chart for signals related to denomination-oriented discrimination. FIG 8 is a drawing used to explain denomination-oriented discrimination.

1 ... amplifying circuit

2 ... multiplexer

3 ... analog-to-digital conversion circuit

4 ... memory circuit

5 ... integrating circuit

6 ... discriminating circuit

7 ... slice level memory circuit

8 ... comparator

9 ... counting circuit

10 ... timing signal generating circuit

11 ... discrimination control circuit

23 ... bank note indicator

24 ... detector

FIG 1 is a block diagram of the bank note discriminating device in a working example of the present invention.

1 ... amplifying circuit

2 ... multiplexer

3 ... analog-to-digital conversion circuit

4 ... memory circuit

5 ... integrating circuit

6 ... discriminating circuit

7 ... slice level memory circuit

8 ... comparator

9 ... counting circuit

10 ... timing signal generating circuit

11 ... discrimination control circuit

23 ... bank note detector

24 ... detector

FIG 2 is a drawing of the sensor array in the device shown in FIG 1.

21 ... conveyor route

22 ... bank note

23 ... bank note indicator

24 ... detector

25 ... light source

26 ... light-receiving sensor

27 ... light source

28 ... light-receiving sensor

□ Direction of Bank Note Conveyance

FIG 3 shows an example of a detection signal S_1, a sampling clock signal t_3 and a sampling data signal S_5.

FIG 3 (a) shows an example of a detection signal S_1.

[x-axis] detection signal S_1

[y-axis] level

FIG 3 (b) shows a sampling clock signal t_3.

FIG 3 (c) shows a sampling data signal S_5.

[x-axis] sampling data signal S_5

[y-axis] level

FIG 4 is a timing chart of the output from the timing signal generating circuit.

FIG 5 shows the content of the memory circuit.

FIG 6 shows the relationship between the sampling position of a bank note and the content of the memory circuit.

□ Direction of Bank Note Conveyance

Bank Note

FIG 7 is a timing chart for signals related to denomination-oriented discrimination.

FIG 8 is a drawing used to explain denomination-oriented discrimination.

□ Reference Value

B1 ... 10,000 A / 10,000 B / 5000 B / 5000 C / Other

B2 ... Other / 10,000 C / 1000 B / 5000 A / 1000 A

B3 ... Other / 10,000 C / 10,000 D / 1000 B / 1000 C

B4 ... 10,000 B / 10,000 D / 5000 C / 1000 C / Other

B5 ... Other / 5000 A / 5000 B / 5000 D / 1000 D

B6 ... Other / 10,000 A / 5000 D / 1000 A / 1000 D

□ Integrated Value I

B1 ... 10,000 A / 5000 A / 5000 C / 1000 A / Other

B2 ... Other / 10,000 B / 10,000 D / 1000 B / 1000 C

B3 ... Other / 10,000 B / 5000 C / 5000 D / 1000 B

B4 ... 10,000 C / 5000 A / 5000 B / 1000 D / Other

B5 ... Other / 10,000 A / 10,000 C / 5000 D / 1000 A

B6 ... Other / 10,000 D / 5000 B / 1000 C / 1000 D

□ Count Result